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Endovascular treatment of central thoracic venous stenosis and occlusion in hemodialysis patients

Endovascular treatment of central venous diseases

Erdem Birgi, Onur Ergun, Hasanali Durmaz, Azad Hekimoğlu, Işık Conkbayır, Baki Hekimoğlu
Department of Radiology, University of Health Sciences, Diskapi Yildirim Beyazit Training and Research Hospital, Ankara, Turkey

Abstract
Aim: This study aims to present the endovascular treatment of symptomatic central venous stenosis or occlusion in patients with ipsilateral native arteriovenous fistula or graft.
Material and methods: A total of 21 patients with central venous disease were reviewed retrospectively. The patients were referred with swelling in the arm, neck, or both and inadequate or unsuccessful dialysis sessions. The location, length, and extension of the stenosis/occlusion were evaluated by diagnostic venography and angioplasty with or without stenting was performed. The patients were monitored until the termination of follow-up, renal transplantation, complete loss of ipsilateral vascular access, or death.
Results: The technical success rate was 90.5%. The mean follow-up period for the patients who received successful treatment was 12.53 months. The primary patency rates at 3, 6, and 12 months were 89.4%, 61.1%, and 50%, respectively.
Discussion: Endovascular interventions performed in cases of central venous occlusion and stenosis are technically successful, safe, and effective in terms of short-term results. However, patients should be under close follow-up and be prepared for repetitive interventions due to low patency rates in the long term. To prevent the emergence of central venous pathologies, unnecessary, prolonged, and repetitive central venous catheterizations should be avoided.

Keywords
Arteriovenous Fistulas, Balloon Angioplasty, Endovascular Procedures, Stents, Veins

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Corresponding Author: Erdem Birgi, University of Health Sciences, Diskapi Yildirim Beyazit Training and Research Hospital, Department of Radiology, Şehit Ömer Halisdemir Street, No: 20, 06110, Ankara, Turkey.
E-mail: ebirgi@gmail.com P: +90 536 574 43 22
Corresponding Author ORCID ID: https://orcid.org/0000-0001-7808-7300

Introduction

Central venous stenosis and occlusion, defined as central venous disease (CVD), occurs as a result of venous intimal hyperplasia of over 50% in the superior and inferior vena cava, internal jugular, subclavian, or brachiocephalic veins and is one of the most important causes of vascular access dysfunction in patients undergoing hemodialysis via arteriovenous fistula or graft (AVF/AVG) for a prolonged duration [1, 2]. Although CVD can be seen at rates between 1.5% and 17% in patients undergoing dialysis, rates as high as 40% have been reported in some series [3-5].

The most important causes include central venous damage resulting from long-term catheterization and hemodynamic stress secondary to the high flow caused by AVF/AVG [2].

Today, the first choice in the treatment of central venous pathologies is the endovascular method, which includes percutaneous transluminal angioplasty (PTA), bare stents, and covered stents [6]. However, there is no consensus on which option is optimal.

This study aims to share our experience in the endovascular treatment of central venous disease in patients with ipsilateral native AVF suffering arm or neck swelling accompanying dialysis difficulty.

Material and Methods

Patients

This retrospective study was approved by the ethics committee of our hospital. All patients included in the study were informed verbally and in writing before the procedure was commenced, and their consent was obtained. The study was conducted in accordance with the Declaration of Helsinki.

In this study, patients who underwent endovascular treatment due to central venous stenosis or occlusion in our interventional radiology unit between 2012 and 2020 were reviewed.

The patients were referred to us from in-hospital and less commonly out-of-hospital dialysis centers after experiencing severe swelling in the relevant arm, neck, or both and inadequate or unsuccessful dialysis sessions.

The inclusion criteria were undergoing dialysis via AVF/AVG due to CKD and the presence of symptomatic central venous stenosis or occlusion. Patients who did not have AVF/AVG but developed central venous stenosis secondary to central venous catheterization and dialysis patients with fistula dysfunction but no central venous pathology were excluded from the study.

A total of 21 patients, of whom 16 were men (76.2%) and five were women (23.8%), were included in the study based on the aforesaid inclusion criteria, and their mean age was 60.29 years (range: 35-86 years, SD: 13.39).

Diagnosis and treatment

Before the procedure, arteriovenous Doppler US examination of the upper extremity with AVF was carried out for all patients. Patients with no fistula-level or peripheral vascular pathology but suspected of central venous pathology were referred for venography for further examination.

For venography, images were obtained under fluoroscopy (Siemens Artis Zee, Erlangen, Germany) with the manual injection of 20 mL of contrast agent after achieving appropriate venous cannulation from the relevant extremity.

Venous access was performed under US and local anesthesia (5-10 mL, 2% lidocaine) with a single puncture. A 5-French (F) or 6-F vascular sheath (Cordis Corp., Switzerland) was initially placed for diagnostic venography. The location, length, and extension of the stenosis/occlusion were evaluated in diagnostic venography. While upper extremity access was sufficient in patients with stenosis, femoral venous access was also used to show the length and extension of the occlusion in cases of occluded lesions. The stenotic or occluded segment was first attempted to be passed primarily through a 5-F vertebral catheter (Penty, Barty Medical, China) or a 0.035-inch support catheter (Rubicon 35, Boston Scientific, USA) using a 0.035-inch straight-tipped hydrophilic coated guidewire (Glidewire®, Terumo, Japan). A 0.035-inch, stiff-body occlusion wire (Roadrunner® PC Hydrophilic Wire Guide, Cook Medical, USA) with hydrophilic and stiff features was used for patients with failed attempts and chronic occlusion. In cases where this wire-catheter combination failed, the combination of a 0.018-inch support catheter (CXI Support Catheter, 2.6 F, Cook Medical, USA) and a 0.018-inch straight-tipped wire (V-18 Control Wire, Boston Scientific, USA) was used. In cases where the proximal or distal part of the occlusion could not be passed, another attempt was always made on the other side. After ensuring that the correct lumen was accessed based on the contrast agent upon the passage of the lesion, the access was secured with a 0.035-inch exchange stiff guidewire (Amplatz Super Stiff, Boston Scientific, USA). At this stage, a vascular sheath of 7-10 F was placed over the existing stiff wire in accordance with the diameter of the balloon, stent, or both to be used. To facilitate the passage of large-diameter balloons through occlusions, first, pre-dilatation was performed using small-diameter (4-6 mm) balloons. Then the PTA (XXL™, Boston Scientific, USA/Armada 35, Abbott, USA) was applied 2 or 3 consecutive times, each lasting at least 2 minutes, using balloon catheters of 1-2 mm wider than the adjacent patent vessel (8-18 mm, most often 12 mm). The patency degree and possible complications such as extravasation were checked in angiograms after PTA (Figures 1). In patients found to have residual stenosis of >50% in the lumen, a self-expandable bare stent of the same diameter or 2 mm wider than the first balloon catheter was placed (Epic™ Vascular, Boston Scientific, USA/Venous Wallstent™, Boston Scientific, USA), depending on the location and extension of the lesion. During the procedures, 3000 units of intravenous unfractionated heparin were administered. Anticoagulant or

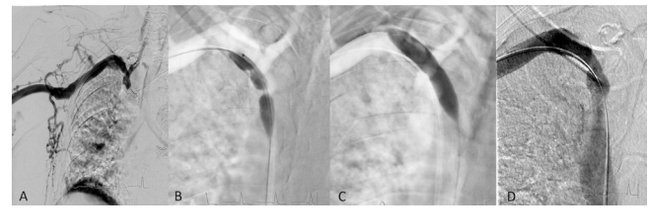

Figure 1. Patient with severe stenosis in the distal section of the right subclavian vein and occlusion of the right brachiocephalic vein origin (A), who had balloon indentations at the levels of stenosis and occlusion during PTA (B). Complete dilatation of the balloon is seen (C) and post-PTA venography showed complete patency of the occlusion and the contrast agent filling into the vena cava superior (D).

antiplatelet therapy was not given to the patients after the procedure.

The patients were monitored until the termination of their follow-up by our hospital, renal transplantation, complete loss of ipsilateral vascular access, or death.

No significant residual stenosis (>30%) after the procedure and completion of the treatment without complications were defined as technical success, non-passable lesions as technical failure, and primary patency as the continuous patency interval from the first procedure to the next endovascular intervention. The classification system of the Cardiovascular and Interventional Radiological Society of Europe (CIRSE) was used to assess the complications [7].

Statistical analysis

Numerical data were presented as average, standard deviation, median, maximum, and minimum, while categorical data were pre¬sented as number and percentage. Editing and analysis of statistical data were per¬formed using SPSS 25.0 (IBM Corp., USA).

Results

All 21 patients included in the study presented with AVF/AVG; upper extremity, neck, or chest swelling; and difficulty in dialysis. The right side was affected in seven patients (33.3%) and the left in 14 patients (66.7%). The brachiocephalic vein was the most affected vein, either alone or in combination with other veins in 76.2% of the patients (16/21). In 23.8% of the patients (5/21), the subclavian vein was involved alone. After diagnostic venography, 61.9% of the patients had occlusion (13/21) and 38.1% had stenosis (8/21). Stenoses were in one segment in six patients (75%) and were multiple in two patients (25%). In-stent stenosis was observed in five of the previously treated patients (Figures 2 and 3). The mean occlusion segment length was found to be 3.31 cm in patients with occlusion (range: 2-8 cm, SD: 1.75).

Five (26.3%) of the 19 patients who were successfully treated within the scope of the study received more than one intervention in different sessions. The vast majority (80%) of those who underwent more than one procedure consisted of patients who were stented previously. In two patients with central venous occlusion, although attempts were made to pass through the occluded segments using combinations of the upper extremity and femoral venous access, the procedure was unsuccessful because the occlusion could not be passed through. A total of 30 procedures performed in the remaining 19 patients were successful. Based on the initial procedure performed, the technical success rate was calculated to be 90.5% (19/21).

Before the first session treatments, only PTA was applied in seven of the eight stenoses detected by venography, and PTA with stent was applied in the remaining one stenosis. Only PTA was applied in seven of the 11 occlusions, and PTA with stent was applied in the remaining four occlusions. When repeated attempts were also considered, of all the 30 procedures, only

Table 1. Patients demographic, central venous lesion and procedure related data

Patients		
Female	5	23.8%
Male	16	76.2%
Mean age	60.29 years	(range:35-86 years, SD: 13.39)
Central venous lesions		
Right	7	33.3%
Left	14	66.7%
Occlusion	13	61.9%
Stenosis	8	38.1%
Single	6	75%
Multipl	2	25%
Mean occlusion length	3.31 cm	(range:2-8 cm, SD:1.75)
Endovascular treatment		
PTA	19	63.3%
PTA and stent	11	36.7%
Mean follow up	12.53 months	(range:4-29 months, SD:6.69)

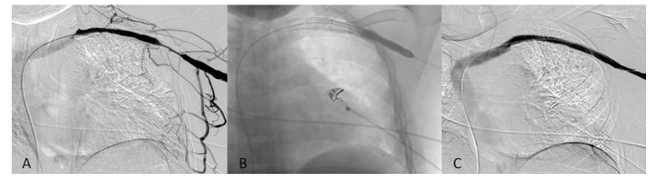

Figure 2. In a 45-year-old man with a history of multiple stent placements extending from the left subclavian vein to the axillary vein and cephalic vein who presented with swelling in the arm and difficulty in dialysis, venography revealed serious stenosis in the stent at the level of the axillary vein (A). After performing balloon angioplasty (B), complete patency was achieved (C).

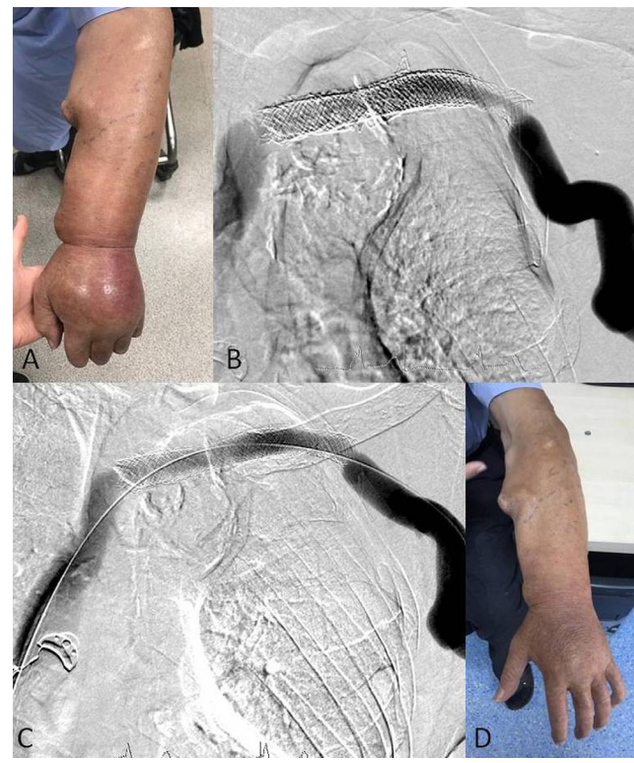

Figure 3. In the venography of a 70-year-old man who had left arm edema and problems in dialysis (A), short segment steno-sis was detected in the proximal part of the stents in the left subclavian vein (B). After balloon angioplasty at the stenosis level, full patency was achieved (C) and edema in the left arm regressed the next day (D).

PTA was applied in 19 and PTA with stent in 11.

In addition to being treated for central venous stenosis or occlusion, during the repeated attempts made before or after the first session, a total of three different patients also underwent thrombolytic therapy along with PTA for a thrombus in the fistula efferent vein.

The mean follow-up period for the 19 patients who received successful treatment was 12.53 months (range: 4-29 months, SD: 6.69), and the primary patency rates of the patients who received endovascular treatment (only PTA and PTA + stent) at 3, 6, and 12 months were 89.4%, 61.1%, and 50%, respectively, according to short-term follow-up results.

No minor or major complications were encountered during the endovascular treatment or follow-up of the patients included in the study. The demographic information of the patients and the data concerning their central venous lesions and the procedure are summarized in Table 1.

Discussion

CVD often occurs as a complication of central venous catheterization and interrupts dialysis sessions from the ipsilateral upper extremity AVG/AVF [6]. Central venous damage secondary to venous catheterization and the subsequent inflammatory response trigger intimal hyperplasia, resulting in central venous pathology [8].

Cannulation of the subclavian veins results in 50% stenosis, and the right internal jugular vein has the lowest rate among the central veins. Therefore, it is necessary to avoid subclavian vein catheterization in patients with AVF/AVG or those that are likely to be accessed through AVF/AVG in the future [9-11]. In our study, it was found that subclavian vein involvement was less common than involvement of other central thoracic veins, which might be because more attention is recently being paid to this issue during central venous catheterization. In their study, Nael et al. encountered central venous occlusion at a rate of 11% in venography performed for patients with dialysis dysfunction and reported that they reached this low rate by preventing subclavian vein catheterization [11].

Primary patency rates after surgical reconstruction of mediastinal veins in hemodialysis patients are better than those of endovascular treatments; they are reported to be 80-90% for one year. However, these major surgical interventions are often difficult to apply in this group of patients who already suffer from many comorbid diseases [12].

Today, endovascular treatments have satisfactory results in addition to being less invasive and having high rates of technical success. Although there is no clear consensus on the optimal option in the treatment of central venous pathologies, the primary treatment method recommended for central venous lesions is percutaneous angioplasty [6, 13]. Inadequate flow during the post-PTA procedure or early postop period is a valid indication for stent placement [14].

PTA and stenting paradoxically cause venous neointimal hyperplasia in the long term. Efforts to prevent this are increasing in interventional treatments, and the use of covered stents and paclitaxel-coated balloons has gained prominence with the aim of improving long-term patency [8].

There are many studies in the literature comparing PTA and stenting retrospectively. In these studies, the primary patency rates of the different techniques were compared and there was no consensus on which method was better due to the lack of randomized controlled studies on this subject. The primary patency rates of only PTA were reported to be 58%, 23-63%, and 12-53% at 3, 6, and 12 months, respectively, while the primary patency rates of bare stents were 63-100%, 42-89%, and 14-73% at 3, 6, and 12 months, respectively [15-17].

Among the reasons for the difference in the patency rates in different studies is that the protocols applied, stent types used, study populations, and the treated veins differ [18]. Based on these results, we agree that it would be better to consider endovascular treatment as a complete therapy where ballooning, bare stenting, and covered stenting are used. The treatment decision should be made on a case-by-case basis by considering the patient's previous intervention history, the location and extension of the existing lesion, the presence of residue after the procedure, and the clinical state of the patient. Following the successful endovascular treatments in our study, the 3-month, 6-month, and 12-month primary patency rates were calculated to be 89.4%, 61.1%, and 50%, respectively.

The National Kidney Foundation Disease Outcomes Initiative (KDOQI) guidelines published in 2006 recommend PTA as the preferred method regardless of whether a stent is subsequently placed [14]. While deciding on the endovascular treatment in central venous lesions, as recommended by most authors and guidelines and in line with the principle of "leave nothing behind," we believe that the primary treatment should always be PTA. Ozyer et al. reported that the number of repeated attempts was higher in stenting than in ballooning and that stenting should be used not as a primary treatment method but only in resistant or recurrent lesions after PTA [18]. Similarly, in our study, the number of repeated attempts was higher in patients who underwent stenting. However, this difference could be attributed to the fact that stenoses that require stents tend to be more resistant.

Technical success in the recanalization of central veins has been reported to be over 90% in most studies [19]. We found a similarly high rate of 90.5% in our study.

The self-expandable stent options used in our treatment were first-generation wall stents and second-generation nitinol stents. Nitinol stents have high flexibility and are resistant to kink development. In two different studies, it was reported that there was no significant difference between wall stents and nitinol stents [20, 21].

In some studies, it has been shown that nitinol stents have better patency rates than wall stents [8, 22]. In a recent study, Gür et al. showed that when compared with steel stents, nitinol stents have significantly longer primary and secondary patency results [8]. On the other hand, it has been reported that covered stents potentially reduce the intimal hyperplastic response, but there are not enough studies in the literature regarding their efficacy [1].

Extravasation of the contrast agent while trying to pass through the segment in the occlusion with the guidewire by resorting to difficult manipulations is a pathology in favor of local venous rupture, and it regresses spontaneously in most patients without the need for additional intervention. Late complications

include stent fracture, which occurs mainly when the stent is inserted to the subclavian vein at the level of the clavicle, and stent migration due to stenting with inappropriate sizes. Stent fracture can be prevented by preferring self-expandable nitinol stents with high radial strength, while stent migration can be prevented by adequately oversizing the measured vein diameter [2-6].

One limitation of our study is that the number of patients for whom only PTA was applied and the number of patients who were stented along with PTA were insufficient for comparison. Also, due to the lack of long-term follow-up data, only short-term patency rates of the patients could be calculated.

Conclusion

Endovascular interventions performed in cases of central venous occlusion and stenosis are technically successful, safe in terms of complications, and effective in terms of short-term results. These patients should be under close follow-up and be prepared for repetitive interventions due to low patency rates in the long term. Additionally, to prevent the emergence of central venous pathologies, unnecessary, prolonged, and repetitive central venous catheterizations should be avoided.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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